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Emu Meat Research and Product Development Towards a Niche Market for ISPECL

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Emu Meat Research and Product Development

Towards a Niche Market for ISPECL

***i.e.*, International Specialty Production of Emu Co-op Ltd.**

ADF Project # 20000303

Final Report

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ABSTRACT

The objectives of this study were to ascertain the nutritional value (*i.e.*, macro and microconstituents) of emu meat and a jerky product derived from it. Of particular interest were the contents of creatine, creatinine and phosphocreatine in emu meat and how these bioactives were affected by processing operations during the production of a value-added meat product. For comparative purposes, beef counterpart samples were prepared. A jerky prototype from emu meat was formulated and found to be highly acceptable by representatives of the Canadian Emu Oil Saskatchewan Ltd. The proximate compositional data indicated that emu meat and the jerky prepared from it were not so different from their beef analogues. Analysis of the microconstituents revealed that the levels of a number of nutritionally important oil- and water-soluble vitamins and minerals were typical of those for red meat species. The creatine content in emu meat and the resultant jerky product was similar to that of beef; however, the emu jerky contained slightly more creatine than the beef product. This demonstrates a great potential for emu jerky to be considered as a functional foods for athletes looking for performance enhancement, and who are interested in consuming greater quantities of creatine from a natural source.

TECHNICAL REPORT

Meat from ratites is perceived and marketed as a healthy alternative to other red meats due to its leanness and a favourable fatty acid profile. For example, the intramuscular fat of ostrich contains 16.5% polyunsaturated omega-3 fatty acids. Game and exotic meats are gaining more attention in the marketplace, and an increasing number of markets are capitalizing on this interest.

Emu meat is a red meat and has double the iron content of beef. Its consumption is recommended by the American Heart Association because of its low fat and cholesterol contents. Farmed emu is a viable livestock and a farm diversification option. As a specialty livestock, emus have three main products: fat [oil], meat and hides. A typical emu to market will weigh 80 lbs at 15-18 months. It will yield 26 lbs of boneless red meat, 17 lbs of fat and 6 to 7 square feet of hide. Several emu oil markets are already in place unlike emu meat markets. Development of such markets will insure a profitable return to the emu farmer; hence, further research on emu meat and value-added products derived therefrom could greatly facilitate this option.

The sports nutrition market may offer a specialty niche market to emu producers. As with so many market statistics, estimates of the size of the sports nutrition market vary widely, depending on types of products included and distribution channels. The Nutrition Business Journal, for example, reported that sports nutrition products – in the form of supplements, bars and drinks – racked up $4.7 billion in consumer sales in 1999, a 10% rise over 1998. Emu meat has been touted as a good source of protein, B vitamins, bioavailable iron and creatine. Throughout history, athletes have searched for performance-enhancing agents. Creatine (*N*-[aminoiminomethyl]-*N*-methyl glycine) has been marketed as an ergogenic dietary supplement, thereby catering to the needs of athletes looking for a performance edge. Unlike previous claims of aids, however, there appears to be scientific merit to the claim that creatine is ergogenic when taken in sufficient quantities. Consequently, creatine is used by a large number of fitness and muscle building enthusiasts. It is usually supplemented as a monohydrate salt and is available at health and/or natural food stores. Its consumption was found to increase the concentration of this nitrogenous compound as well as its phosphorylated counterpart in muscle tissue, thereby enhancing muscular strength. Although results are contradictory, the overall evidence suggests that creatine has the ability to improve activities where bursts of motion occur. The mechanisms behind its benefits involve creating kinases, an enzyme that fosters the formation of adenosine triphosphate (ATP) and phosphocreatine, energy liberating and recycling compounds in muscles. Although creatine supplementation has been shown to enhance short-term, high-intensity exercise performance, data indicate that creatine supplementation does not enhance aerobic exercise performance. While creatine supplementation will likely increase high-intensity strength performance (*i.e.*, power lifting) in many athletes, there are few data to support its use by endurance athletes.

The objectives of this study were to ascertain the nutritional value (macro and microconstituents) of

emu meat and a jerky product derived from it. Of particular interest were the contents of creatine, creatinine and phosphocreatine in fresh emu meat, a formulated jerky batter as well as the resultant cooked product, and how these bioactives were affected during the processing operations.

Material and Methods

Meat Samples

Fresh emu meat was obtained from the Canadian Emu Oil Saskatchewan Ltd. (Carlyle, SK). The birds were electrically stunned and their necks were cut for exsanguination, where after the feathers and skin were removed. The carcasses were then chilled and the fan fillets were excised from the carcass 24 h after slaughter and shipped to the pilot plant facilities of the Department of Applied Microbiology and Food Science at the University of Saskatchewan in Saskatoon.

Fresh beef inside rounds (aged for 21 days) from young Canada Grade A carcasses were purchased from a beef packer (XL Meats, Calgary, AB). The *semimembranosus* muscles were removed and trimmed of all visible fat and connective tissue before processing.

Preparation of Emu and Beef Jerkies

The emu muscles supplied by the Canadian Emu Oil Saskatchewan Ltd. were trimmed of all visible connective tissue and ground through a 3/16" plate with a four-blade knife. The comminuted muscles were weighed and transferred to a glass vacuum mixer. All dry ingredients to be used in the jerky product were preweighed and kept separate. Sea salt and curing salt (*i.e.*, Prague powder) were added to the comminuted meat and mixed in for 2 min at 24 rpm. The water and remaining dry ingredients were then added and mixed for 4 min at 24 rpm. The meat batter was transferred to a Handtmann VF 80 vacuum filling machine and stuffed as strips approximately 33 mm × 3 mm onto stainless steel screens coated with vegetable oil. The trolley holding the product was transferred to an Alkar Batch Oven (Alkar, Lodi, WI, USA) and thermally processed until a water activity of less than 0.85 was recorded; the formulation for the jerky product is listed in Table 1 and the cook schedule is reported in Table 2.

Samples of the fresh ground meat, formulated jerky batter and the final cooked product were acquired. For comparative purposes, a beef jerky was prepared in a similar fashion, as described above, from the *semimembranosus* muscle tissue; samples of the fresh ground meat, batter and final jerky product were also taken. One hundred gram portions of collected samples were lyophilized (Labconco Freezone-12, Kansas City, MO) and stored in sealed glass vials in a desiccator at 4°C until analysed.

Proximate Analysis

The following chemical constituents were determined (AOAC, 1990) on samples of the lean ground meat, batter and processed jerkies: moisture content by drying 2.5 g sample at 104°C to a constant weight (950.46b.a); ashing at 500°C to a constant weight (920.153); crude protein content by the classical macro Kjeldahl method (981.10); fat content by petroleum ether extraction using a Goldfisch apparatus (960.39a); and % dextrose equivalents by an iodometric titration methodology for meat samples from Health Canada. All samples were analysed in duplicate for chemical composition. Water activity of jerky products was determined using a Decagon CX-1 water activity meter and was calibrated using a saturated NaCl solution.

Mineral Analysis

Minerals were determined from the lyophilized meat preparations using a microwave digestion of each sample followed by an inductive-coupled plasma (ICP)-atomic emission spectroscopy protocol. For iodine, however, the analysis was carried out by neutron activation using a Slowpoke reactor at SRC Analytical (Saskatoon, SK). The minerals determined were aluminium, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iodine, iron, lead, magnesium, manganese, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, titanium, vanadium, zinc and zirconium.

Creatine, Creatinine and Phosphocreatine Analysis

Sample Preparation
Samples of freeze-dried fresh meat, batter and jerky were pulverized using a clean mortar and pestle. A portion was extracted with 0.5 M perchloric acid according to Harris *et al.* (1974. Glycogen, glycolytic intermediates and high energy phosphates in biopsy samples of musculus quadriceps fermoris of man at rest. Methods and variance of values. *Scand. J. Clin. Lab. Invest.*, **35**, pp. 85-97). Acid extracts were neutralized with 2.1 M $KHCO_3$. One milliliter of neutralized extract was equivalent to 10 mg of muscle powder. Standards of creatine, creatinine and phosphocreatine were purchased from Sigma-Aldrich Canada Ltd. (Oakville, ON) and prepared in neutralized perchloric acid at concentrations ranging from 20 to 1000 μM.

Chromatography
The content of creatine, creatinine and phosphocreatine were determined by isocratic reverse-phase ion-pairing high performance liquid chromatography (HPLC). A Waters HPLC system was employed and consisted of the following components: a Waters 600 controller, a 600R multi-solvent delivery system, a 996 photodiode array detector (DAD), a 715 Ultra Wisp sample processor and Millenium software. Conditions of separation entailed an analytical C_{18} LUNA column (5 _m, 4.6 _

250 mm, Phenomenex, Torrance, CA); mobile phase was an aqueous solution of KH_2PO_4 [14.7 mMol, 2.0 g/L] and tetrabutylammonium hydrogen sulphate [2.3 mMol, 0.8 g/L] adjusted to pH 5.0 with KOH; a flow rate of 1 mL/min; an injection volume of 20 _L; and the detector was set at 210 nm. The mobile phase was prepared freshly each day. Concentrations of creatine, creatinine and phosphocreatine were determined by comparing sample peak heights to those of external standards.

Vitamin Analysis

Lyophilized samples of fresh emu meat, the formulated jerky batter and the resultant cooked product were analysed for their vitamin contents. Official methods from the US Pharmacopoeia were used for analysis of the oil- and water-soluble vitamins. An HPLC assay was employed for all determinations, but depending upon the vitamin in question, the diode array detector was set at different wavlength maxima. For vitamin A (USP 24 NF 19:2346 - method 3) detection was carried out at 325 nm; for vitamins E and K_1 (modified USP 24 NF 19:2346) detection was at 254 nm; for vitamin D_3 (USP 24 NF 19:2346 - method 1) detection was at 265 nm; for vitamin B_{12} (USP 24 NF 19:2364) detection was at 550 nm; for folic acid (USP 24 NF 19:2366 and LB-CJ-05 p97-101) detection was at 280 nm; and for biotin (USP 24 NF 19:2363 and LB-CJ-05, p87-89) detection was at 200 nm.

Results and Discussion

Table 1 presents the final formulation used in the preparation of the emu and beef jerkies. Although a number of formulations were developed and tested, this one offered the best taste and texture to the end product, as assessed by an untrained panel. Representatives of the Canadian Emu Oil Saskatchewan Ltd. also tested the emu jerky for its acceptability before any of the chemical analyses were performed; the resultant value-added emu meat product was deemed to be a great success. Table 2 outlines the cooking schedule employed in the jerky manufacture. This is important, as thermal destruction of vitamins, amino acids, peptides and bioactive constituents in the jerky may occur during processing. For this reason, the basic chemical composition and content of bioactives (*i.e.*, in this case: creatine, creatinine and phosphocreatine) of the fresh meat, jerky batter before thermal processing and cooked end product were measured. Such data will address the question as to whether or not processing affected the macro and microconstituents of emu meat during the preparation of the value-added meat product. A parallel beef product was prepared for comparative purposes, as beef jerky is the accepted product on the market. Compositional information on emu jerky will greatly assist the penetration into niche markets such as those of athletes, health food stores or gourmet markets.

Table 3 presents the proximate compositional analysis of emu meat & beef and the jerkies prepared therefrom. There was no marked compositional difference between fresh emu meat and beef, except perhaps that beef contained slightly more protein. This could be important if one wanted to compare creatine levels in the beef and emu on an equal protein basis. After incorporating the additives to the formulation, the carbohydrate content in the product increased, as denoted by higher % dextrose equivalent contents in the batter and final jerky product. The product was thermally processed until the jerky achieved a water activity of 0.85 or less. Attaining a value of 0.85 or less denotes that the jerky is shelf-stable and that there is no fear of microbial spoilage. The proximate analysis reflected the low moisture contents in both the emu and beef jerkies. Simultaneously there was a marked increase in the protein and carbohydrate percentages. From the compositional analysis, one can unequivocally state that the jerkies represent a good source of protein. The question remains, however, as to the effect of processing on the creatine, creatinine and phosphocreatine levels.

Table 4 presents the content of oil- and water-soluble vitamins in fresh emu meat, the formulated jerky batter and the resultant cooked product. Because the compositional analysis of macro and microconstituents is influenced by the moisture content in the sample, the results are presented on a dry weight basis; thus, comparisons can easily be made. Concerning the oil-soluble vitamins: only vitamins A and E were detected in fresh emu meat, the batter and jerky product. Assuming that there is no destruction of vitamin A during thermal processing, its endogenous content in muscle tissue should remain constant. A higher level was detected in the batter and jerky end product; this indicates that vitamin A is being incorporated into the formulation from an exogenous source (*i.e.*, the prune puree). On the other hand, there is no supplementation of vitamin E during batter preparation, as the content of vitamin E in the fresh meat, batter and resultant cooked jerky product is approximately the same (*i.e.*, when one compares the results on a dry weight basis). Of the water-soluble vitamins, it was surprising that no vitamin B_{12} was detected. Folic acid was found only in the batter and jerky, perhaps originating from the prune puree. Biotin, on the other hand, was detected only in the final jerky product. A footnote in Table 4 includes the detection limits of the assay for each vitamin.

Table 5 presents the mineral analysis of fresh emu meat, the formulated jerky batter and the final product. In total 26 minerals were analysed. Data for each mineral in a sample (*i.e.*, fresh meat, batter and jerky) are presented in units of μg/g sample on a wet weight basis or μg/g sample on a dry weight basis. Direct comparisons can be made between data presented on a dry weight basis. The increase in the mineral content between fresh emu meat and the formulated batter (or jerky end product) is the result of mineral supplementation from the various additives. The best example of which is the increase in the sodium levels as a consequence of salt addition. Comparison of the mineral content of fresh emu meat with those of other red meat species indicates that there is no marked differences.

Creatine, $C_4H_9N_3O_2$, is present in muscular tissue of many vertebrates and is commercially isolated

from meat extracts. Although small amounts occur in the blood, it is not found in the urine of man. Rather, the greater part of creatine in muscle is combined with phosphoric acid as phosphocreatine. This is produced by the liver and kidneys by the transfer of the guanidine moiety of arginine to glycine, which is then methylated to give creatine. Creatinine, $C_4H_7N_3O$, is the end product of creatine catabolism. It is a constituent of the urine with a daily output of about 25 mg per kg of body weight. It is also found together with creatine in muscle tissues and blood. Figure 1 depicts the chemical structure of these three compounds.

Accurate determination of both creatine and creatinine requires the resolution of these two compounds from the unretained peak and from each other to be maximized. HPLC chromatograms revealed that the standards purchased from Sigma-Aldrich had good peak symmetry and were well resolved when a mixture of them was injected onto the column, based on the method described in the Materials and Methods section. Retention times for creatine, creatinine and phosphocreatine were 2.34, 2.86 and 25.52 min, respectively, based on the separation conditions described. Investigation of peak area vs concentration of standards demonstrated a linear relationship when up to 100 μg/ml of each standard were injected onto the column. Based on nine data points (*i.e.*, for concentrations varying between 1 and 100 μg/ml), linear correlation coefficients for creatine, creatinine and phosphocreatine were r^2 = 0.9998, 0.9995 and 0.9997, respectively. Separation of creatine, creatinine and phosphocreatine was equally good in muscle extracts as with standards, although only trace quantities of phosphocreatine were detected in fresh meat samples. Peak purity appeared good with no obvious evidence of co-elution with interfering compounds. The contents of creatine, creatinine and phosphocreatine in the fresh meat, formulated jerky batter and final cooked product from emu and beef are presented in Table 6. Results from triplicate determinations are presented as mg compound/100 g sample or mg compound/g dry matter. Only direct comparisons can be made between results presented on a dry weight basis.

Trace quantities of phosphocreatine were detected in the samples analysed, and not in all cases; this is not surprising as phosphocreatine would be expected to be present in the muscle tissue of live animals, but deleted once the muscle tissue had passed through rigor mortis and been converted to meat. At this later point, the majority of ATP deposits in muscle tissue, and its precursors, would be consumed. Moreover, not even traces of phosphocreatine were detected in the jerky product, which suggests that if any were present in the fresh meat, it was broken down to possibly creatine or creatinine during thermal processing. Creatine levels were significantly greater than those of its catabolised product, creatinine. This is significant and indicates both emu and beef are good sources of creatine and that value-added meat products derived therefrom can be considered as functional foods. Creatine levels were slightly greater in the fresh ground beef, but its important to remember that the compositional analysis indicated that there was a slightly higher protein content in beef than in emu meat. After thermal processing, however, slightly higher levels were detected in the emu jerky than its beef counterpart. This is further reflected when the data is presented on the basis in which the product is delivered (*i.e.*, mg of creatine/100 g jerky product). Thus, this demonstrates a

great potential for this product to be considered as a functional food for athletes looking for performance enhancement, and who are interested in consuming greater qualities of creatine from a natural source.

OTHER PERSONNEL INVOLVED

Dr. Ryszard Amarowicz, Docent/Assistant Professor, from the Department of Food Chemistry, Division of Food Science, Institute of Animal Reproduction and Food Research of Polish Academy of Sciences, Olsztyn, Poland, and Ms. Heather Silcox, Analytical Services, Department of Applied Microbiology and Food Science, have contributed time to this project.

PROJECT DEVELOPED MATERIALS

Jerky prototypes were made available to representatives of the Canadian Emu Oil Saskatchewan Ltd. A manuscript entitled, "Emu Meat and Meat Products: Nutraceutical Potentials" by RB Pegg, R Amarowicz and B Code, has been prepared with the intent of publication in the Elsevier journal, *Meat Science*, but only after review and approval by Dr. B Code.

ACKNOWLEDGEMENTS

The financial support by SAFRR's Agri-Value Program has been gratefully acknowledged in the manuscript described above.

Table 1. Developed jerky formulation.

Ingredients	Formulation (%)
Ground meat (either emu or beef)	88.57
Water	1.00
Sea salt	1.80
Dextrose	3.00
Brown sugar	1.00
White sugar	1.00
Black pepper	0.20
Prague powder (*i.e.*, cure)	0.28
Sodium erythorbate	0.05
Garlic powder	0.10
Prune puree	3.00
Total	100

Table 2. Thermal processing schedule for the jerky using an Alkar batch oven.

Step	Dry bulb (°C)	% RH	Time (h)	1 Blower	3 Steam Humidity	5 Dampers Closed	6 Smoke Gen. off	7 Slow Fan	11 Dwell Smoke on
0	60		0.04	X		X	X	X	
1	71		0.06	X		X		X	X
2	82	24	2:00†	X	X			X	

†The jerky was processed until a water activity of 0.85 or less was reached. RH – relative humidity.

Table 3. Proximate compositional analysis of emu meat & beef and the jerkies prepared therefrom.

Assay†	Emu			Beef		
	Fresh	Batter	Jerky	Fresh	Batter	Jerky
Moisture (%)	76.3	70.6	31.9	74.1	69.5	29.9
Crude Protein (%)	20.1	18.6	44.0	21.4	18.6	44.3
Lipid (%)	1.2	0.9	2.2	1.6	1.2	2.8
Carbohydrate (% dextrose eq.)	0.4	6.0	14.5	0.4	5.9	14.4
Ash (%)	2.3	3.0	7.1	1.6	2.9	7.0
Total	100.3	99.1	99.7	99.1	98.1	98.4
Energy (kcal/100 g)	92.8	106.5	253.8	101.6	108.8	260.0
Salt (%)	0.22	1.94	4.79	0.26	1.82	4.58
pH	5.43	5.49	5.53	5.30	5.29	5.46

†Results are means of duplicate determinations.

Table 4. Content of oil- and water-soluble vitamins in fresh emu meat, the formulated jerky batter and the cooked product.

Vitamins	Emu[†] Fresh	Batter	Jerky
Oil soluble vitamins (μg/g d.m.)			
Vitamin A	0.203	1.03	0.966
Vitamin E	3.66	3.87	3.98
Vitamin D_3	n/d	n/d	n/d
Vitamin K_1	n/d	n/d	n/d
Water soluble vitamins (μg/g d.m.)			
Vitamin B_{12}	n/d	n/d	n/d
Folic acid	n/d	9.26	11.23
Biotin	n/d	n/d	12.5

[†]Detection limits for vitamins A, E, D_3, K_1, B_{12} as well as folic acid and biotin are as follows: 0.021, 0.100, 0.021, 0.100, 0.200, 1.36 and 2.4 μg/g, respectively. Results are means of duplicate determinations. n/d – not detected; d.m. – dry matter.

Table 5. Mineral analysis of fresh emu meat, the formulated jerky batter and the cooked end product[†]

Mineral	Fresh Emu Meat		Emu Batter		Emu Jerky	
	μg/g meat	μg/g d.m.	μg/g batter	μg/g d.m.	μg/g jerky	μg/g d.m.
Aluminium	0.7	3.0	7.2	25	14	21
Barium	<0.05	<0.05	0.23	7.8	0.45	6.6
Beryllium	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Boron	0.5	2.1	1.5	5.1	3.5	5.1
Cadmium	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Calcium	50	210	120	410	280	410
Chromium	0.17	0.72	0.1	0.34	0.23	0.34
Cobalt	0.10	4.2	<0.05	<0.05	<0.05	<0.05
Copper	2.3	9.7	1.9	6.5	4.4	6.5
Iodine	<0.3	<1	<1	<1	<3	<3
Iron	50	211	45	150	110	160
Lead	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	250	1050	340	1160	800	1170
Manganese	0.30	1.3	0.84	2.9	1.8	2.6
Molybdenum	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel	<0.02	<0.02	<0.02	<0.02	0.16	0.23
Phosphorus	2300	9700	1900	6500	4700	6900
Potassium	3100	13100	4000	13600	8400	12300
Selenium	1.1	4.6	0.84	2.9	1.9	2.8
Silver	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sodium	470	1980	8500	28900	19200	28200
Strontium	0.06	0.3	1.7	5.8	3.9	5.7
Titanium	<0.05	<0.05	0.15	0.51	0.33	0.48
Vanadium	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	36	150	27	92	71	100
Zirconium	<0.01	<0.01	<0.1	<0.1	<0.1	<0.1

[†] < denotes not detected at the level stated. Results are means of duplicate determinations and are presented as μg/g sample in the actual state and μg/g d.m. (dry matter). The detection limits varied for each sample due to the different sample matrices. At any rate, the reported detection limits are the lowest achievable for each sample type. Residual moisture contents in freeze dried emu samples for fresh meat, batter and jerky were 2.3, 8.0 and 12.1%, respectively, these percentages were factored in when determining μg/g d.m.

Table 6. Creatine, creatinine and phosphocreatine analysis in fresh meat, the formulated jerky batter and cooked end product from emu and beef[‡].

Analyte	Fresh Meat		Batter		Jerky	
	mg/100 g sample[§]	mg/g dry matter	mg/100 g sample[§]	mg/g dry matter	mg/100 g sample[§]	mg/g dry matter
Emu						
Creatine	695	29.31±1.93	661	22.47±0.28	1553	22.81±0.55
Creatinine	5.64	0.238±0.015	5.59	0.190±0.009	79.7	1.17±0.037
Phosphocreatine	tr	tr	tr	n/d	n/d	n/d
Beef						
Creatine	786	30.37±1.98	749	24.55±0.23	1518	21.66±0.48
Creatinine	23.3	0.901±0.006	20.2	0.662±0.031	123	1.75±0.051
Phosphocreatine	tr	tr	n/d	n/d	n/d	n/d

[‡]Residual moisture contents in freeze dried samples for fresh meat, batter and jerky from emu & beef were 2.3, 8.0, 12.1% & 2.6, 11.6, 11.8%, respectively. These percentages were factored in when determining mg contents/g dry matter. Results are means ± standard deviation of triplicate determinations. tr – trace amounts detected; n/d – not detected.

[§]Values reported were calculated based on the mean values (mg/g dry matter) and moisture content.